

# TROUBLESHOOTING HIGH SPEED COUPLINGS

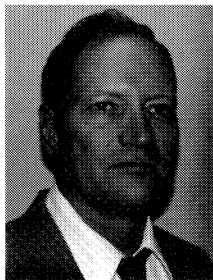
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*Colombia Nitrogen Corporation, Tenneco Chemicals and Tenneco Oil. Current activities center on field assistance in reciprocating and turbomachinery problems, including repair techniques, modernization, alignment, and onstream diagnoses of critical rotating equipment.*

## ABSTRACT

Couplings are a major concern of turbo equipment users. Couplings can and do result in many hours of lost sleep for the plant equipment specialists, and can cause failure of equipment resulting in extended periods of downtime. They are often overlooked during major turnarounds. A user's guide for troubleshooting and general inspection of inservice couplings is presented.

Couplings, relatively small in comparison to the equipment they tie together, play a major role in the operation of that equipment. When a machine is down, these essentials may not be considered as a source of failure. While information is readily available for installation of couplings, few references are available regarding the inspection and repair of these items. Repair not only involves servicing the coupling, but also the removal and installation of the components.

The need for an overall checklist covering these procedures prompted this presentation. Gear, diaphragm, and laminated couplings are addressed. The proper coupling-to-shaft fit and how to achieve an 80 percent plus contact is covered. This presentation does not get into the field of retrofitting couplings, but provides an excellent information resource for those seeking help in the inspection field.

This hands-on approach does not cover engineering design or OEM preference, but it offers engineers material for coupling repair not readily provided in other manuals. The step-by-step outline is essential for both veteran and novice troubleshooters seeking help in the area of coupling inspection and repair.

## INTRODUCTION

In today's world of high tech, engineers are always trying to improve on what they have. All too often, they try to replace something that is not working properly rather than looking for the root cause of the problem itself. It is all too easy to pick up the telephone, call a supplier, and say "I want to retrofit an exist-

ing unit." Many hours are spent engineering, preparing justification, and waiting on long deliveries when what is needed is a close inspection and proper installation and application of an existing piece of equipment.

Another frequent problem is "the dumb mechanic" in the field can't fix it. A close look at the mechanic reveals he was never instructed on the proper method of doing the job. All the instructions are hidden in the engineer's or supervisor's desk so they will not get lost. If there is a plant full of "dumb mechanics," it is because engineers and supervisors made them that way.

## TROUBLESHOOTING

Coupling problems are very hard to pinpoint. Usually an equipment history file is the best starting point. Without that, the following is offered:

### *Total Failure*

*Driver runs, but driven does not.*

### *Vibration Problems*

This is where we normally start.

- Harmonic greater than two times running speed
- Both driver and driven are thrusting inboard or outboard.
- Both inboard or both outboard radial vibration increases.

## COUPLING REMOVAL, GEAR TYPE

Information is readily available on coupling installation procedures; however, guidance for removal is considerably harder to find. Steps typically followed during the removal disassembly procedure include:

### *Open Coupling Guard*

- Note oil nozzle orientation.
  - Direction with reference to rotation.
  - Are the orifice openings plugs in place?
  - Are the orifice openings plugged up?
- Bolts.
  - Are they all there?
  - Are they all tight?
  - Are they all the same? Length (possibly stretched), diameters, strength (original and/or current).
- Spool piece and sleeves
  - Are they free to move by hand or with a light tap?
  - Is there excessive diametrical clearance between the sleeve and hub (before removal)? Two mil is considered excessive. This should also be checked on installation.
  - Is corrosion present?

### *Remove Spool Piece*

- Check match marks before removal
  - Spool to sleeve
  - Sleeve to hub
- Keep the coupling bolts as a nut and bolt set. This is how they are weight-balanced. If a problem is suspected, weigh each bolt and each nut. They should be weight balanced within 0.1 grams.

- Use jack bolts to separate the spool from the sleeve.
- Note the amount of sludge. Gear couplings by their nature are excellent oil centrifuges and, dependent upon cleanness of oil system, considerable sludge can be expected. This sludge can typically cause a coupling “lockup” and will result in equipment vibration. Some users and OEMs have adopted an antisludge design on their couplings. Others have installed elaborate filter systems. Some have done both.

- Check condition and torque of the shaft nut.

#### *Mike and Record “as is” Position of the Hub on the Shaft Hub Removal*

- Removal of the coupling nut. Please use proper wrench. A pin-punch and ballpeen hammer do not replace a spanner wrench.

- Hydraulic fit. This is the only application where information was readily available on coupling removal. The entire procedure will not be covered.

- Furnish the working personnel with sufficient copies of the procedure. Let everyone know how it is to be done.

- Condition of special tools. Where have these tools been stored? Have all the pieces been accounted for? Are all the lines and fittings perfectly clean? One grain of sand could be worth a fortune if found before it gets in the fit. Do you have the proper hydraulic fluid available?

- Standard keyed couplings

- Where is the puller attached? Hopefully, the coupling was installed with the face drilled for puller bolts. The author has seen couplings installed backwards on some straight shafts. Do not use the coupling sleeve or hub teeth. This is said with tongue-in-cheek, because there are occasions when these are the only places to pull.

- Attach the puller using only Grade 8 cap screws or B-7 studs. *To prevent personal injury and equipment damage from a flying hub, the shaft nut should be installed at least two full turns on the shaft. Note:* These drilled and tapped holes are not standard. They must be specified when ordering a coupling.

- Make sure the puller has a “live center” that conforms to the shaft center. Acorn type shaft nuts have been used to protect the shaft center when additional protection is required.

- Use of the “Blue Tip Wrench.” What is it about the color cherry red that excites people? It seems to be so much fun to watch the teeth of a coupling glow. Should you have to use a torch, the following is suggested: Rotate the shaft while heating. Use a 300°F temperature stick to check hub. The teeth can reach two to three times this temperature when heat is applied. If 300°F is exceeded, the coupling should be returned to the OEM or a coupling specialty shop for inspection. Most high performance coupling teeth have been nitrided and overheating can upset or destroy this treatment.

- Steam can also be used to heat the hub.

### COUPLING REMOVAL, DRY TYPE

The same basic procedure is used but with the following exceptions:

- Lube system check is not needed.
- A flange-to-flange dimension should be recorded prior to hub removal.
- Extra care must be used in handling the diaphragm type. Any burr or dent in the diaphragm will create a stress point and lead to early failure.

### COUPLING INSPECTION

#### *Gear Type*

- Wash in a good solvent. Remember, a coupling is a precision piece of equipment.

- Visually inspect the gear teeth on both hub and sleeve. Look for:

- galling.
- pitting.
- Excessive normal wear.
- Signs of electrostatic discharge. (The author has replaced old and new couplings, because nothing else worked, and it did solve the problem.)

- Hub bore—check for fretting.

- Keyways
  - Key fit, 0 to 1.0 mil loose side-to-side is standard.
  - Do the corners have the proper radius?

- NDT all parts. Check for residual magnetism.

- Bolts and Nuts

- Some OEMs recommend replacement after a specified number of reassemblies. These are special aircraft quality, and cannot be found just anywhere.

- Check bolt length for signs of overtorquing.

- Check shoulder surfaces for signs of wear.

- Weight-check bolts and nuts in sets. Per December 1971, API Std. 671-2.5.1.2. “Each bolt and nut that must be removed for normal field assembly of the coupling shall be separately weight-balanced to a tolerance of 0.1 gram.”

- Check radial fit between gearing.

- Inspect spool piece to hub fit.

- Are surfaces clean and smooth?

- Are there signs of fretting?

- Are the bolt holes symmetric?

- Are surfaces flat? Check for high spots.

- Are all oil passages open?

- Check-balance each component. The author recommends the OEM or a coupling specialty shop.

#### *Dry Type*

Some coupling diaphragms are coated for corrosion protection; a scratched coating can result in failure. They should be stored in a wooden or cardboard box to protect them. Also the spool pieces on some couplings have protected covers on the spool side of the disc; dirt and debris can collect and limit the disc movement. Check!

### COUPLING BORING

It has been found that a new hub is required and the spare has not been bored. The following steps are suggested if a set of rings and plug gauges are not available. (See API 671 or vendor guides for machining tolerances and indicating surfaces for setup.)

#### *Make Sure the Spare Blank is the Right One*

- Match up sleeve and spool piece.
- Check overall dimensions of new parts to original in-service parts.

- Check oil porting on lubricated couplings.

- Compare spool piece length.

- Cutting the Bore

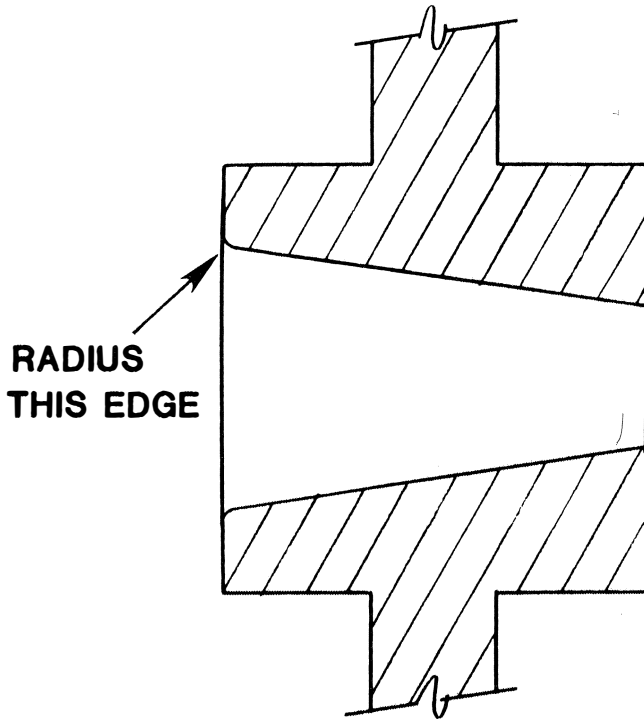
- Use a sample piece of material, equal in size to the new hub, to check the taper setup.

- Blue this sample to the shaft. Make sure to use Prussian blue and not layout blue. There is a big difference. Contact area should be 80 percent or better. Check position of blank on shaft. A 1.0 mil increase in bore on ½ in per foot tapers will alter the axial position by about 12 mils and potentially result in insufficient coupling float.

- Only when a good sample piece fits correctly on the shaft should final machine work start on the spare hub. (Figure 1) *Note:* Some unbored coupling hubs may require dressing down

of the tooth crown to achieve proper internal clearances between hub and sleeve.

- After final boring, put a radius on the edges of the bore. Some shaft failures have been diagnosed as cracks due to stress points created by the sharp edge of the coupling bore. Be sure keyway corners are radiused with a smaller radius than the radius on the key.



## COUPLING HUB

Figure 1. Radius Coupling After Boring.

## COUPLING TO SHAFT CONTACT

### *Bluing the Coupling—Taper Fits*

- Clean the shaft with a lint-free rag. The author does not like paper towels because they will leave fibers behind.
  - Check shaft and hub for obvious burrs. Use a stone, not a file, to remove any high spots.
  - Clean the shaft again.
- Apply a *very* thin and even coat of Prussion blue. This does mean thin. You are not trying to grease pack a bearing.
- Slip the hub on the shaft by hand until tight without keys. Rotate the hub  $\frac{1}{8}$  turn, then back to the original position.
- Remove and check for 80 percent contact.

### *Obtaining 80 percent Contact When Needed*

- Lapping the hub to the shaft: This is a very dangerous practice and extreme care must be used. The author does it, but only under personal supervision. It is *your* coupling and turbo shaft (Figures 2 and 3).

- Obtain some AAA or 500 grit lapping compound.
- Apply a light coat evenly around the shaft.
- Work the hub on the shaft for 20 to 30 seconds. This is not

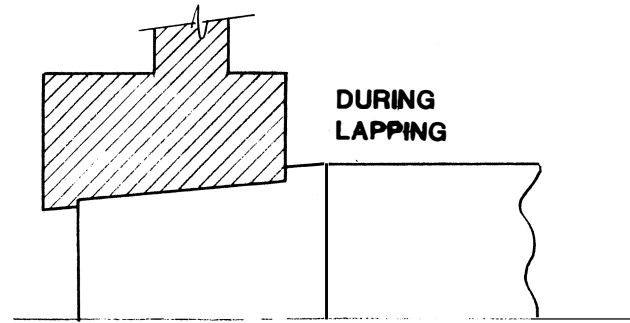


Figure 2. Effect of Lapping Coupling on the Shaft.

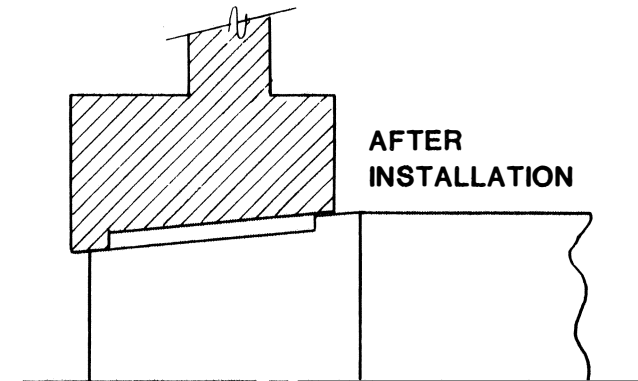


Figure 3. Result of Lapping the Coupling on the Shaft.

to be done more than once. Its purpose is to remove very minor high spots that prevent obtaining a good blue check of the fit.

- Thoroughly clean the shaft and hub.
- Repeat step *Bluing the Coupling—Taper Fits*
- If 80 percent contact is achieved, hone down the shaft area of taper past the lapping marks (Figures 4 and 5). Make sure this area is lower than the lapped surface. Also remove the ridge inside of the hub.
- Fabrication of lapping blocks—cast iron blocks may be machined when excessive lapping is required. When lapping a shaft in the horizontal position, the ring block should be as light-

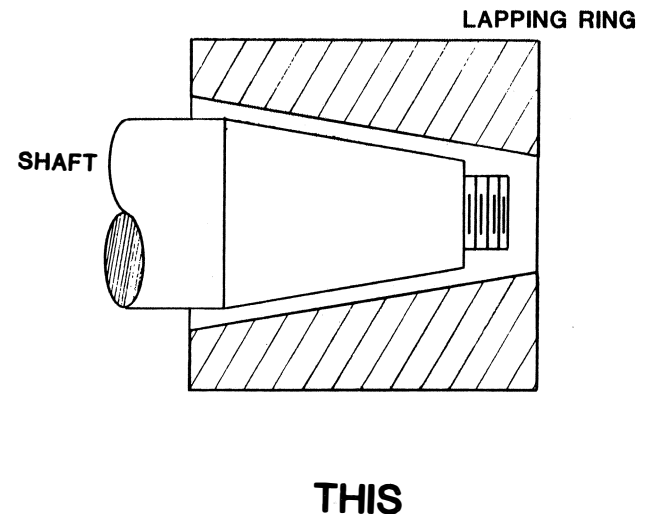
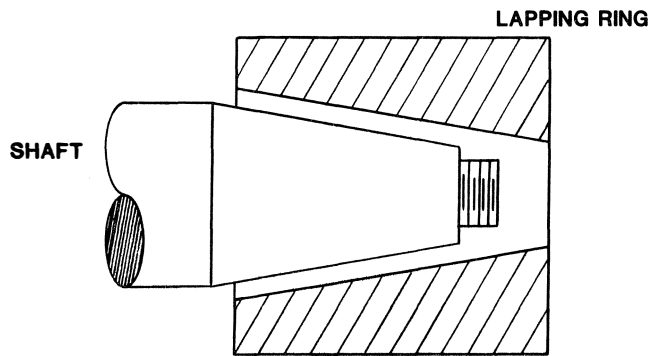


Figure 4. Correct Lapping Ring.

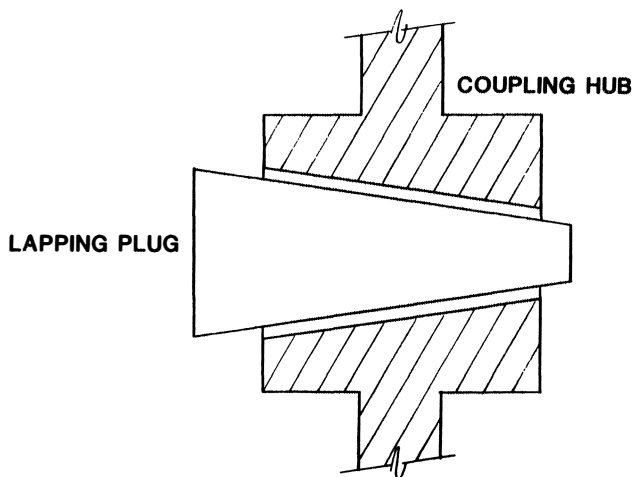


**NOT THIS**

Figure 5. Incorrect Lapping Ring. It is too short on the big end.

weight as possible to avoid removing metal from only the top side of the shaft.

- After machining lapping ring and plug, check the tapers by bluing to a good shaft or coupling hub. (Figures 6, 7, and 8)



**THIS**

Figure 6. Correct Lapping Plug.

- Make sure the ring width extends over both ends of the shaft taper and the plug extends out both ends of the hub.
- Use 300 or finer grit lapping compound.
- Recheck contact after each three to five minutes of lapping.

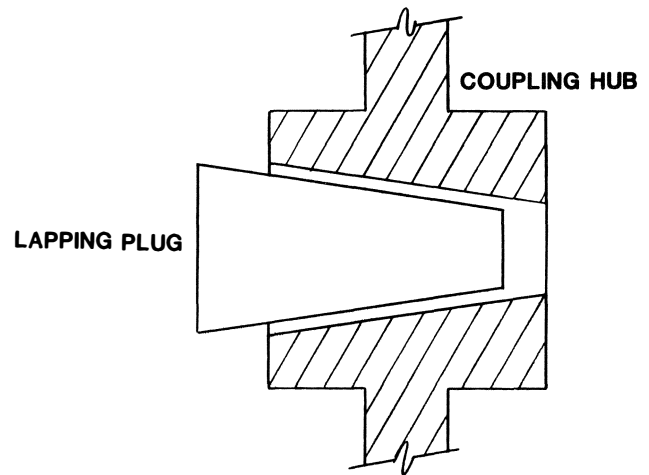
#### COUPLING INSTALLATION ON SHAFT

It will be assumed that the alignment and shaft spacing are correct.

Gear Coupling Hub and Sleeve Must Match

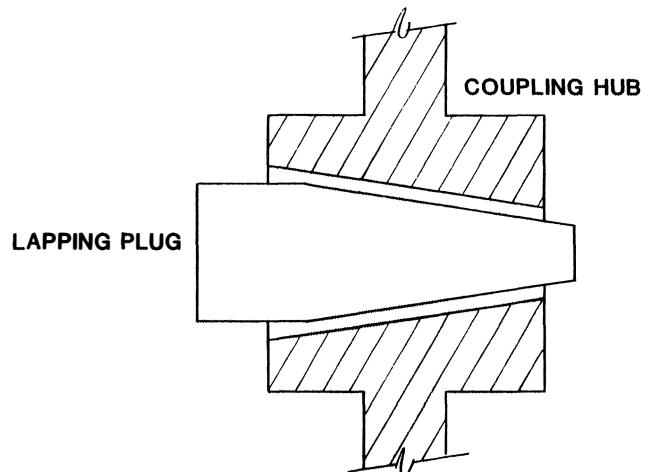
Place Hub on Shaft Hand-tight

- Check and record hub position.



**NOT THIS**

Figure 7. Incorrect Lapping Plug. It does not go all the way through.



**NOT THIS**

Figure 8. Incorrect Lapping Plug. It goes too far in.

- Erect a stop to position the hub in the desired position at final mounting. Two short pieces of 3/8 in key stock and a hose clamp are recommended. The keys are positioned 180 degrees apart, parallel to the shaft. A feeler gauge is used to position the keystack and the hose clamps lock them in place. The required interference between hub and shaft varies from 0.5 to 2.0 mils/in of shaft diameter. Should you increase the current interference, remember this will also increase the pulling force required to remove the coupling. It also reduces the radial clearance in geared parts. The author's company uses 1.0 mil/in of diameter as a nominal figure.

- Make sure the hub extends over the end of the shaft at least 60 mils plus the amount of travel used for final installation (Figures 9 and 10).

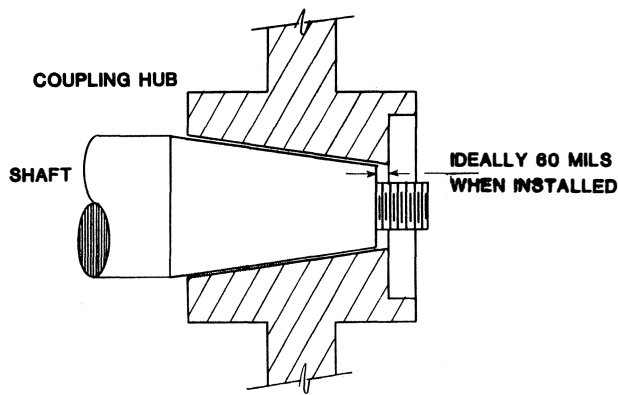


Figure 9. Positive Hub Overhang.

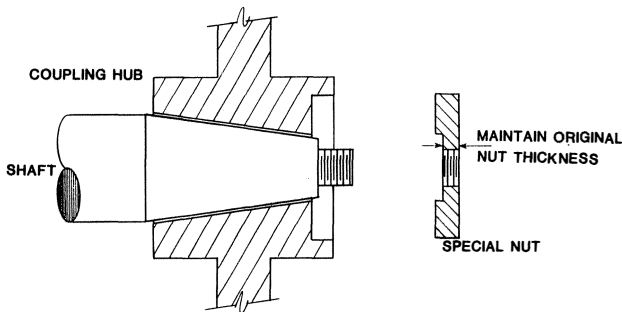


Figure 10. Negative Hub Overhang. Requires special nut.

#### Fit the Keys

- Each key should slide or lightly tap in place.
- The key should have 10 mils of clearance between the top of the key and the hub. Check your OEM or API specifications.
- All key edges should be rounded.
- Match mark each key to its slot.
- Any part of the key extending past the end of the hub should be machined off flat with the shaft to preserve balance. The face of the key should be at least 10 mils shorter than the shaft shoulder at the nut.

#### Check the Shaft Nut

- Clean it.
- Deburr it.
- Try it on the shaft.
- You may want to blue it to the hub in order to check contact.
- Inspect the set screws.

#### Heating the Hub

Some people prefer to install the hub cold; the author likes to heat it.

- Types of heat
  - Open flame—least desirable
  - Oven
  - Oil bath
  - Induction

- 300°F should be sufficient to install any coupling—calculate expansion of a specific application. (Steel expands 0.67 mils/in/100°F.) Normally a 150 degree differential between hub and shaft is sufficient for installation.

- Large couplings should not be heated faster than 50 degrees per half hour.

- On gear couplings, make sure the right sleeve is on the right shaft, and turned in the correct direction. *Note:* On grease-pack couplings, make sure all O-rings or seals are in place.

- Using two pieces of all-thread screwed into the puller holes as handles, slide the heated hub onto the shaft. Remove the all-thread, insert the keys, and use the shaft nut to advance the hub up to the positioning keystone.

## FINAL ASSEMBLY

### Dry Type Couplings

- Check hub-to-hub dimensions against data in the specifications.
- Install spool piece and use a torque wrench to tighten all bolts.
- Install coupling guard.

### Gear Type Couplings

- On grease-pack units, install the appropriate amount of specified grease. Sometimes the grease is frozen to allow time for spool piece installation.

- On continuous lube units, install the spool piece and check end float. Try to have the two shafts in their normal running position. Most gear couplings require  $\frac{1}{8}$  in to  $\frac{1}{4}$  in float. Check the specifications.

- Install lube spray nozzles. *Note:* Nozzle orientation with reference to the rotation of the coupling.

- Turn on the oil pump.
- Check lube spray.
- Recheck sleeve-to-hub diametrical clearance.
- Install coupling guards.

## “GOOD LUCK”

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